Reducing Atmospheric Carbon Dioxide through Soil Sequestration

Carbon combustion contributes to urban industrial pollution.

Challenge

Atmospheric concentrations of carbon dioxide are on the rise because of increased fossil-fuel combustion, deforestation, and other land-use changes. Moderating this trend will require major changes in the way carbon is managed in the environment. The U.S. Department of Energy (DOE) is exploring various methods for controlling carbon dioxide levels — from increasing energy efficiency to carbon sequestration. In the long term, new technologies will be needed to capture, isolate, and store carbon before it reaches the atmosphere; but technological fixes like these could take 30 to 50 years to develop and implement. In the meantime, more immediate solutions are crucial.

Argonne's Solution

Argonne researchers and their collaborators are focusing on ways to enhance the natural ability of terrestrial ecosystems to remove carbon dioxide from the atmosphere via photosynthesis and then convert the organic carbon to stable forms. Increasing natural sequestration in long-lived terrestrial sinks, such as wood or soil, is expected to be an important near-term carbon- management strategy.

The Laboratory is developing new methods to separate soil into fractions that have distinct functions. Using established stable-isotope tracer techniques, scientists can look for fractions in which the rate of decomposition is slow and the capacity for additional carbon accumulation is high. Once scientists know where to look for sequestered carbon, they will be better able to measure, model, and predict the sequestration potential of different management practices and soil types.

Approach

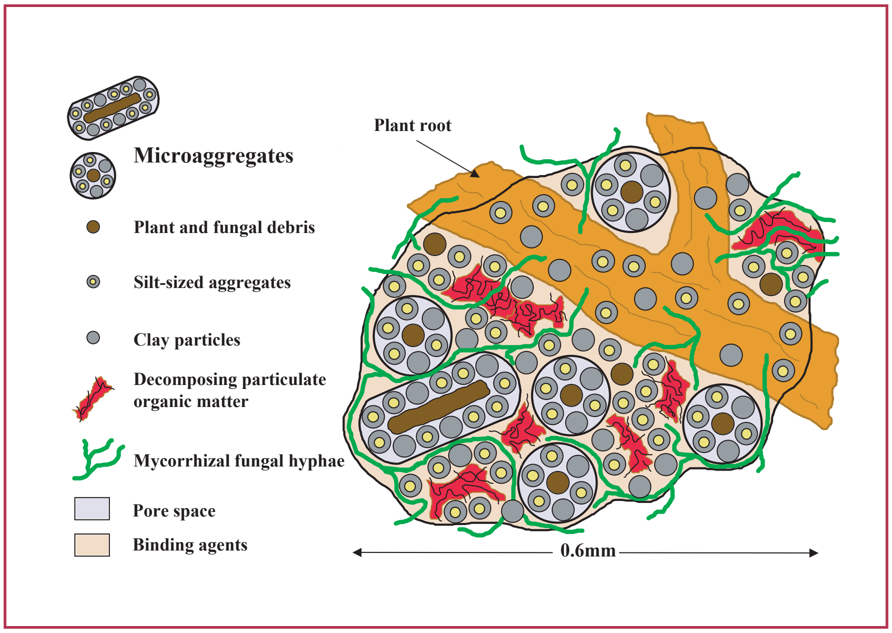
Argonne's approach to fractionating soil is based on a mechanistic understanding of how organic matter cycles through soils. Plant growth and the decomposition of organic matter lead to physical and chemical associations with soil minerals that organize soil components into aggregates. The aggregated state protects organic matter from decomposition and creates carbon pools with longer residence times.

Soil aggregates often have hierarchical structural organization and stability. Together with its collaborators at Colorado State University, the Argonne has developed a novel technique that uses sequential application of appropriate disruptive energies to fractionate soil according to its organizational levels.

Soil core shows aggregate of different sizes.

Accomplishments

Argonne's fractionation approach has been applied to soils in which the conversion of native prairie to pasture grasses about 50 years ago altered the natural abundance of stable carbon isotopes in the vegetation, creating a tracer for organic inputs occurring after the switch in vegetation type. In isolated soil fractions, the tracer enables researchers to quantify and compare rates of replacement of old organic matter by new inputs from pasture grasses. Preliminary results indicate that silt and clay within microaggregates contain more new carbon than silt and clay outside microaggregates. These results support Argonne's conceptual models of organic-matter cycling within soil aggregates and suggest that organic carbon protected within microaggregates has the best chance of becoming highly stabilized (sequestered) by chemical association with soil minerals.



Conceptual diagram of the hierarchical organization of a macroaggregate (Jastrow and Miller, 1998, in Soil Processes and the Carbon Cycle, Lal et al., editors, CRC Press).

Benefits

Argonne's fundamental studies of the mechanisms controlling the stabilization of soil carbon will be used to identify management practices that increase the size of protected carbon pools with significantly long residence times. This work, together with the efforts of collaborators in DOE's Center for Research on Enhancing Carbon Sequestration in Terrestrial Ecosystems (CSiTE), will lead to acceptable methods for capturing carbon dioxide from the atmosphere and enhancing the ability of terrestrial ecosystems to store carbon for periods of at least 30 years, preferably 50 to 100 years or more.

Partners

Argonne National Laboratory, along with Oak Ridge National Laboratory and Pacific Northwest National Laboratory, is a member of the CSiTE research consortium established by the U.S. Department of Energy, Office of Biological and Environmental Research, Environmental Sciences Division. Additional CSiTE collaborators include six universities and five other research institutions.

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